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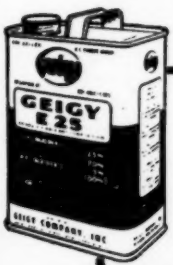

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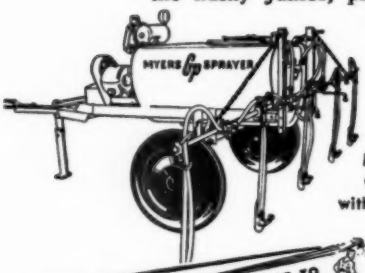

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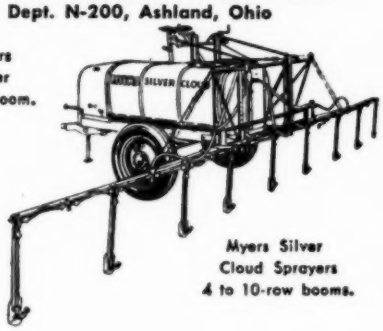

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A STUDY OF THREE FACTORS IN POTATO PRODUCTION: ROW SPACING, SEED SPACING, AND FERTILIZER RATE[1]

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Interest in determining experimentally the effects of different planting distances on the yield of potatoes goes back many years. It is a matter of historical record that some of the first field experiments reported by experiment stations in this country dealt with this problem (2, 5). The effects of different rates of fertilizer on potato yields likewise is a time-honored study. However, the combination of three factors—row spacing, seed spacing, and fertilizer rate—in one experi-

[1]Conducted under cooperative agreement between the Virginia Truck Experiment Station. V. A. Tiedjens, Director; and the Division of Fruit and Vegetable Crops and Diseases, U. S. Department of Agriculture. Acknowledgment is made to H. M. Clark, Superintendent, Eastern Shore Branch Truck Experiment Station (Virginia) for helpful assistance. The work was inaugurated with the help of the late Dr. H. H. Zimmerley whose genuine interest and sound judgment were always of great value to the writers.

[2]Biochemist.

[3]Assistant Director and Horticulturist.

ment so that the individual effects of each might be determined concomitantly with their interactions is at least a new approach to an old problem and offers possibilities for evaluation peculiar to the factorial type of experimental design.

Stated briefly, the objectives of the experimental work here reported were to determine the effects of different seed and row spacings on yield and to measure concomitantly the extent to which seed spacing and row spacing might jointly affect yield production, and to determine also the effects of different amounts of fertilizer on yield, particularly in relation to the different planting distances. Since the three principal factors under study involved the use of different quantities of seed and fertilizer per acre, it seemed especially desirable to estimate the economy of the different planting procedures so that they might be compared on the basis of net returns "beyond" the cost of treatment.

After the first year's crop had been harvested a decision was made to measure also the experimental effects of the different variables on the average size of prime potatoes produced.

Experimental Procedure

The experiments were located on Sassafras sandy loam soil in the vicinity of Onley, Virginia. Although all the experimental fields were regarded as satisfactory for growing potatoes, the production capacity of the field used in 1943 was considered relatively low. The reaction of these soils at planting time ranged from pH 4.6 to 5.2. Each year the fields were planted about the 15th of March, using an assisted-feed potato planter equipped with band-placement fertilizer attachments. The fertilizer distribution mechanism on the planter was carefully calibrated each time before planting commenced in order to assure delivery of the fertilizer at the proper rates; and at the same time the seed-spacing adjustments were also checked. Certified Irish Cobbler seed was used and commercial 5-10-5 fertilizer, 95 per cent neutralized, containing 255 pounds of dolomitic limestone per ton.

The experimental field plan in 1943 consisted of what is generally called a split-plot arrangement. In this first field plan the row spacings, 30 and 36 inches, occupied the main plots and randomly arranged on these were three seed spacings, 10, 15, and 20 inches, and three fertilizer rates, 1,500, 2,000, and 2,500 pounds per acre. However, in 1944 the field plan was changed to a so-called double split-plot arrangement which was used also in 1946. The treatments remained the same in this plan except that the widest hill-spacing distance was reduced to 18 inches, and the fertilizer rates were laid out as main plots, the row spacings as sub-plots, and the seed spacings as ultimate plots.

In the analysis for the latter experimental design three error terms were calculated, one for testing each main effect and its interactions. When planted, the individual plots consisted of 3 or 5 rows 80 feet long, but at harvest in order to eliminate differential spacing effects, the 2 outside rows were discarded. Four replications of each treatment were provided and these, arranged in randomized-block fashion, comprised a total of 72 plots for the entire experiment. In 1945 due to extremely abnormal weather conditions occurring shortly after planting, the growth of the crop was so irregular that the entire experiment had to be discarded, and consequently there are no records for that year.

Results

Effects on Yield and Net Returns

The yields obtained for the 3 experimental years in bushels of primes graded for size only are shown in table 1. In addition, the net returns "beyond" the estimated cost of seed or fertilizer[4] for the stated experimental variables are also given. It will be noted in table 1 that the differences in yield obtained from the two row spacings produced significant variance only in 1946. In that year the rows spaced 36 inches produced an average increase of 41.1 bushels of primes over the 30-inch rows, exceeding the least significant difference for the 1-inch per cent point. This outstanding difference in yield in 1946 may be partly attributed to the early maturity of the vines on the 30-inch row plots, which in every case matured a week to 10 days earlier than those on the 36-inch row plots, thus affording a relatively longer growing period for the plants on the wider-spaced rows. This difference in time of maturity was not observed in 1943 or 1944.

The different seed-spacing distances, on the other hand, had sufficient effect on yields, as is shown in table 1, to produce significant variance each year, but the levels of significance attained in 1943 were higher than in 1946. When a comparison of the variance produced by each of the three factors under study was made, it was evident that seed spacing had a relatively more pronounced effect on yield than had row spacing or fertilizer rate. In general, the yields were increased when the seed was spaced closer, but these increases were not always significant, nor were they always economical from the standpoint of the additional seed required, as will be brought out later.

One exception to the general tendency toward increased yields with closer seed spacing occurred in 1946 when the 10-inch spacing

[4]From these net returns beyond the cost of seed or fertilizer obviously must be deducted all other production costs to arrive at the real net gains, but we are not specifically concerned with these here.

TABLE 1.—*Effect of row spacing, seed spacing, and fertilizer rate on the yield of prime potatoes and on the net returns "beyond" the cost of seed or fertilizer.*

Treatment	1943		1944		1946	
	Yield	Net Returns[1]	Yield	Net Returns[1]	Yield	Net Returns[1]
	Bushels	Dollars	Bushels	Dollars	Bushels	Dollars
	[2]	[3]		[3]	**	[3]
Row spacing:						
30-inch	124.5	102.10	155.6	138.22	206.3	199.06
36-inch	115.7	99.59	190.8	188.66	247.4	256.58
L.S.D. .05	—		—		21.1	
.01	—		—		30.3	
Seed spacing:	**	[4]	**	[4]	*	[4]
10-inch	134.2	101.19	202.1	182.67	218.7	202.59
15-inch	121.8	106.11	180.8	176.91	235.5	242.55
18-inch[5]	104.4	95.35	178.3	180.66	226.3	238.26
L.S.D .05	9.9		13.0		12.3	
.01	13.5		17.4		16.6	
Fertilizer rate:	**		—		—	
1,500 lbs.	128.9	127.68	178.1	186.72	208.8	223.56
2,000 lbs.	123.4	112.08	189.6	191.52	246.8	260.16
2,500 lbs.	108.2	84.84	193.6	187.32	224.9	224.88
L.S.D. .05	9.9		—		—	
.01	13.5		—		—	

[1]Net returns "beyond" the cost of seed or fertilizer (potatoes at $1.20 and seed potatoes at $3.00 per bushel; fertilizer at $36 per ton).

[2]Variance for factor indicated: —, not significant; *, exceeded 5-per cent point; **, exceeded 1-per cent point.

[3]Average seed spacing 15 inches, 1-ounce seed piece.

[4]Average row spacing, 33 inches, 1-ounce seed piece.

[5]In 1943, 20-inch.

produced a lower average yield than either of the two wider seed spacings as shown in table 1. The yields produced by the 15-inch-spaced seed, however, were greater each year than those from the wider seed spacings, and in 2 out of 3 years (1943, 1946) the net returns were also greater. Further decreasing the seed spacing distance from 15 to 10 inches, in the two years mentioned, reduced the net returns obtained. Although 10-inch-spaced seed gave an increased yield of 12.4 bushels over 15-inch spacing in 1943, exceeding the 5-per cent point, the estimated net returns were reduced $4.92, at the price differentials stipulated. These comparisons are of interest because they illustrate the need for considering cost relationships in evaluating the differences in yields obtained where a cost differential is involved.

The three fertilizer rates produced significant yield variance only in 1943. In that year, which was dry, the average yield obtained from the 2,500-pound rate was significantly lower than that from either 1,500 or 2,000 pounds, and as a result the net returns were also sharply reduced. In 1944, also a dry year, the 2,500-pound rate, although showing a slight increase in yield as compared with 2,000 pounds, nevertheless produced about the same net returns as those from 1,500 pounds. In 1946 the 2,500-pound rate again produced a lower average yield and smaller net returns than the 2,000-pound rate. These latter comparisons, although interesting, are open to question statistically, since the variance for fertilizer rates was not significant in 1944 or in 1946.

A comparison of the results from the 30- and 36-inch row spacings (table 1) shows that in 1944 and 1946 the 36-inch spacing gave higher yields and larger net returns than the 30-inch spacing, even though the growing conditions differed during the two seasons and noticeably affected the absolute yields obtained. In 1946, the difference in favor of the wider row spacing amounted to 41.1 bushels and $57.52 estimated net returns per acre. The same comparisons in 1944 show increases of 35.2 bushels and $50.44 per acre for the wider row spacing. In 1943, however, the 30-inch spacing gave a slightly larger average yield (8.8 bushels) and an increase of $2.51 in net returns above that of the 36-inch spacing. However, it should be pointed out that this apparent increase in net returns was offset to some extent by the reduction of 16⅔ per cent in the number of rows worked at the 36-inch spacing. Although the differences obtained between the two-row spacings in 1943 and 1944 are of interest, no statistical significance is attached to them since the variance for row spacing in these years did not reach the 5 per cent point.

Profits from Investment

From table 1 it will be noted that the maximum gross returns from seed use did not always indicate a proportionately large net return "beyond" the cost of seed. In 1943 net returns from the three seed spacings were not appreciably different although there was a maximum range of about 16 per cent in the gross returns from 10-inch- and 20-inch-spaced seed. These results bring out very clearly the fallacy of using gross returns alone as an indication of returns on investment for seed or fertilizer.

Profit is a function of both efficiency and economy of production, and the only valid measure of profit is the net returns per acre "beyond" the cost of investment. To attempt to increase efficiency at the expense of net returns would soon make the enterprise unprofitable. Conversely, to attempt to increase yields at the expense of efficiency in the use of fertilizer or seed would ultimately reduce the rate of profit. Insofar as seed potato use and fertilizer rates are concerned the most profit will be realized from that combination which produces the largest net return "beyond" the cost of both seed and fertilizer. Although it is often tacitly assumed that high potato yields, indicating efficient production and economical land use, are the most profitable, yet a valid estimate of real net profit from such a venture cannot be obtained until the increased cost of seed, fertilizer, labor, and all other production costs required are charged against the selling price of the crop. Increases in yield caused by highly favorable weather conditions are, however, almost clear profit except for the additional handling costs; but yield increases obtained by using more seed or fertilizer if carried far enough will inevitably lead to a point in production where profits will be reduced by the operation of the law of diminishing need (4) and its complement the law of diminishing returns.

Although the net-return figures in table 1 are based on estimated costs of seed potatoes and fertilizer, as well as on an estimated price for No. 1 potatoes, small changes in these estimates will have little relative effect on the net-return values. It will also make little difference under many conditions whether total yields or only yields of No. 1 potatoes are used because the gross returns must then be adjusted for field-run price, which will be lower than that for No. 1 potatoes. In the present experiments the highest estimated returns "beyond" the cost of seed were obtained from the 15- and 18-inch spaced seed in rows 36 inches apart.

Assuming an estimated cost of fertilizer at $36.00 per ton and the selling price of potatoes at $1.20 per bushel, the largest net returns per

acre "beyond" the cost of fertilizer for the 3 years were obtained from the 2,000-pound rate. Increasing the rate to 2,500 pounds per acre reduced the estimated net returns obtained each year. The point at which the net returns per acre "beyond" the cost of fertilizer begin to diminish obviously will depend on several factors, among them the ability of the crop to utilize the additional fertilizer (law of diminishing need); the kind of land and the growing conditions; the cost of the fertilizer; the selling price of potatoes; and above all the judgment and ability of the grower. For these reasons, and there may be others, the upper limits for profitable fertilizer use (maximum net returns from fertilizer) can vary from farm to farm and even from field to field. It is advisable, therefore, to determine these limits actually over a period of years on the land in question wherever possible.

Interactions

From the standpoint of yield, all the various interactions between the three factors studied failed to attain statistical significance, except that for seed spacing x row spacing in 1943 as shown in table 2. These data indicate that in 1943 the row spacings had very little effect on yield with seed spaced 10 or 15 inches apart, but that a highly significant reduction in yield resulted when the row spacing was increased from 30 to 36 inches with seed spaced 20 inches apart. The latter effect undoubtedly accounts for a large part of the reduction in yield obtained for 20-inch seed spacing in 1943 as indicated in table 1. In general, the net returns "beyond" the cost of seed planted as shown in table 2 followed the same trends for row spacing and seed spacing that was obtained during the 3 years, except that the 20-inch spacing with 36-inch rows produced an unusually large reduction in net returns per acre, as might be expected from the corresponding reduction in yield.

Economies in Seed Use

Although the effects of seed spacing and fertilizer use on yield and net returns per acre "beyond" the cost of seed or fertilizer should be determined, if possible, under local growing conditions, there are, however, certain fixed relationships between planting distances and efficient seed use that remain the same regardless of location. Although expenditures for seed constitute an important item in production costs, it is not always fully recognized that slight changes in planting distances that may appear insignificant can have marked influence on the amount of seed potatoes required per acre. It is true that the size of seed piece used will have a direct effect on the amount of seed required per acre,

TABLE 2.—*Effect of interaction row spacing x seed spacing on the yield of prime potatoes and on the net returns "beyond" the cost of seed,* 1943.[1]

Row Spacing		Speed Spacing					
		10-inch		15-inch		20-inch	
		Yield	Net Returns[2]	Yield	Net Returns[2]	Yield	Net Returns[2]
		Bushels	Dollars	Bushels	Dollars	Bushels	Dollars
30-inch		135.2	96.84	121.8	102.36	116.6	107.22
36-inch		132.2	105.66	121.8	109.86	92.1	83.37
L.S.D.	.05	14.1		14.1		14.1	
	.01	18.8		18.8		18.8	

[1]Variance of interaction exceeded 5-per cent point.

[2]Net returns "beyond" the cost of seed (potatoes at $1.20 and seed potatoes at $3.00 per bushel).

but the effect of changes in the planting distances can be even greater. In the present experiments, for instance, widening the row spacing from 30 to 36 inches reduced the seed requirements 16⅔ per cent. On the other hand, widening the seed spacing produced even greater economies in seed use—10 inch to 15-inch, a 33⅓ per cent reduction; 15-inch to 18-inch, 16⅔ per cent; and 10-inch to 18-inch, approximately a 45 per cent reduction. However, by increasing both row spacing and seed spacing even greater effects on seed economy can be attained. For example, changing from 30-inch rows with seed spaced 10 inches apart to 36-inch rows with seed spaced 15 inches apart would effect a reduction of 44.5 per cent in seed required, and with 18-inch seed spacing the reduction would amount to about 54 per cent of the original seed requirement at the closer planting distances. In evaluating the effectiveness of different potato planting distances, therefore, proper consideration should be given to these seed-use differentials. This can be accomplished by calculating the net returns per acre "beyond" the cost of seed in each case.

Effect on Size of Prime Tuber

The effects of the three main factors, seed spacing, row spacing, and fertilizer rate, on the average weight of prime potatoes produced are presented in table 3. It will be noted that the variance for each of the three main factors was highly significant every year except that for fertilizer rates in 1946. The average weight of prime tubers from rows spaced 36 inches apart was 10.9 grams heavier in 1944 than that from 30-inch rows, and in 1946 this increase amounted to 18.9 grams. In both years the increases were highly significant. A similar effect on size of tuber was obtained when the seed spacing distance was widened. Increasing the seed spacing from 10 to 15 inches produced a highly significant increase in the average size of tuber both in 1944 and 1946. However, further increasing the seed spacing from 15 to 18 inches produced smaller increases in weight of prime tubers statistically significant only in 1946. The variance from the interaction of the two factors (seed spacing x row spacing) was not significant either year, indicating therefore that they were acting independently in their effects on size of tuber.

The average weight of prime potatoes was also affected by varying the fertilizer rate from 1,500 to 2,500 pounds per acre, but this effect was not quite so pronounced as that obtained by varying the row or seed-spacing distances. This is in agreement with the results of Chucka *et al.* (1) who found the effect of seed spacing much more pronounced than that of fertilizer rate on the number and weight of U. S. No. 1

TABLE 3.—*Effect of row spacing, seed spacing, and fertilizer rate on the average weight of prime tubers produced.*

Treatment		Average Weight of Prime Tubers Produced	
		1944	1946
		Grams	Grams
Row spacing:		1**	**
30-inch		146.3	109.0
36-inch		157.2	127.9
L.S.D.	.05	7.5	5.5
	.01	10.8	7.8
Seed spacing:		**	**
10-inch		137.9	105.6
15-inch		156.0	120.5
18-inch		161.3	129.2
L.S.D.	.05	7.3	7.4
	.01	9.8	8.9
Fertilizer rates:		**	—
1,500 pounds		141.8	114.5
2,000 pounds		152.1	124.5
2,500 pounds		161.2	116.3
L.S.D.	.05	9.2	—
	.01	14.0	—

[1]Variance for factor indicated: —, not significant; *, exceeded .05 point; **, exceeded .01 point.

potatoes produced in Maine. The variance from fertilizer rates, it will be noted, was significant only in 1944. In that year the 2,000-pound fertilizer rate increased the average weight of prime tubers 10.3 grams over the 1,500-pound rate, and an additional increase of 9.1 grams was obtained with the 2,500-pound rate. Similar increases were obtained in 1946 for 2,000 pounds of fertilizer; but the 2,500-pound rate produced a marked reduction in size of tuber, which undoubtedly helps to account for the reduction in yield for this particular fertilizer rate in table 1, column 6. Apparently the size of tuber and the yield were affected similarly in this case.

INTERACTIONS

The interaction seed spacing x fertilizer rate was the only one that attained significance in 1944. This interaction, however, was not significant in 1946; that year row spacing x fertilizer rate was the only interaction with variance exceeding the 5-per cent level of significance. The data pertaining to these two interactions are given in tables 4 and 5.

TABLE 4.—*Effect of interaction seed spacing x fertilizer rate on average weight of prime tubers in* 1944.[1]

Fertilizer Rate		Seed Spacing and Average Weight of Prime Tubers		
		10-inch	15-inch	18-inch
		Grams	Grams	Grams
1,500 pounds		129.0	155.3	141.2
2,000 pounds		135.2	154.8	166.3
2,500 pounds		149.5	157.7	176.3
L. S. D.	.05—12.7 grams			
	.01—15.9 grams			

[1]Variance of interaction exceeded .01 point.

TABLE 5.—*Effect of interaction row spacing x fertilizer rate on average weight of prime tubers in* 1946.[1]

Row Spacing		Fertilizer Rate (pounds per acre) and Average Weight of Prime Tubers		
		1,500 Pounds	2,000 Pounds	2,500 Pounds
		Grams	Grams	Grams
30-inch		103.5	110.8	112.6
36-inch		125.5	138.2	120.0
L. S. D.	.05— 9.3 grams			
	.01—13.3 grams			

[1]Variance of interaction exceeded .05 point.

It is clear from the results in table 4 that the wider seed spacing generally increased the average weight of tuber but there is also an indication that this effect was more pronounced at the two higher fertilizer rates. In the case of the 1,500-pound fertilizer rate the average tuber weight with 18-inch spaced seed was actually lower than that obtained with 15-inch spacing. Apparently the 18-inch spacing was too wide to enable the crop to make the best utilization of fertilizer at the lowest rate. For each additional 500-pound application of fertilizer above the 1,500-pound rate, the average weight of prime tubers was increased appreciably with 10-inch and 18-inch seed spacings. However, this effect of fertilizer, for some non-apparent reason, was not obtained with the 15-inch seed spacing.

The influence of the interaction row spacing x fertilizer rate on the average weight of tubers presented in table 5 may be ascribed to the effect of 30-inch rows in consistently producing smaller tubers than those from the 36-inch rows, but to an extent which was more pronounced at the two lower fertilizer rates. These interaction results in tables 4

and 5 lead to the conclusion that the effects of the seed and row spacings for the years indicated were not independent of the changes in fertilizer rates.

Discussion

It is recognized, of course, that the adoption of certain cultural practices such as those calling for wider row or seed spacings, which have a tendency to increase the size of tuber, may have the undesirable effect of unduly increasing tuber size with certain varieties under some growing conditions. However, under the experimental conditions prevailing in 1944 and 1946 this did not take place since the average weight of prime tubers ranged from 104 to 176 grams (3.7 to 6.2 ounces). These figures may be compared with 61 grams (2.1 ounces), which was found by the writer (3) to be the minimum weight of a prime-sized potato (Irish Cobbler). As far as the present experiments are concerned the width of rows and the spacing distance of seed have been shown to act independently on the individual weights of primes so that both factors should be considered of equal importance in their influence on the size of potatoes produced.

That the best yields of potatoes were not dependent upon any one of the specific combinations of fertilizer rate and seed spacing studied is indicated by the fact that the interaction seed spacing x fertilizer rate was not significant for any of the three experimental years. From the standpoint of yield and of net returns, however, the 15-inch seed spacing and the 2,000-pound fertilizer rate combination was the most outstanding. Also, from the same standpoint the 36-inch row spacing was somewhat superior to the 30-inch spacing, but further statistical evidence would be required to establish this result conclusively.

Because of the variability in the results that occurred from year to year, consideration was given to the possibility of obtaining a better estimate of residual error through pooling the yields for the 3 years. This procedure was rejected, however, when the error variances for the main effects were found to be non-homogeneous by the chi-square test. This result ordinarily would be expected since a 3-year period is usually too short to provide an adequate sample of seasonal variation from the standpoint of yields produced. Nevertheless, the unique features of the factorial experimental design permit an interesting evaluation of the individual yearly results as main effects and interactions.

In actual practice, potato growers undoubtedly will want to determine the best combination of seed spacing, row spacing, and fertilizer rate for their own local conditions, but in doing this they should not

underestimate the importance of the economic considerations involved. The yields or gross returns obtained by arbitrarily increasing the amounts of potato seed or fertilizer used will ultimately reach a production limit for any set of growing conditions. The type of gross returns curve obtained under any specific combination of cost-price relationships of seed, fertilizer, and potatoes will in turn determine the point of maximum net returns "beyond" cost and will likewise set the pattern for the operation of the law of diminishing returns. Any potato-growing venture will in a large measure depend upon these important economic and production factors for its financial success.

Summary

Field experiments were conducted in 1943, 1944, and 1946 at Onley, Virginia, to study three factors in potato production: row spacing, seed spacing, and fertilizer rate.

A factorial field design was used which made possible the evaluation of main effects and interactions for 30- and 36-inch row spacings, 10-, 15-, and 18-inch seed spacings, and 1,500-, 2,000-, and 2,500-pound fertilizer rates. These effects were determined on yield and size (weight) of prime tubers.

The results from the three variables were also evaluated on the basis of the net returns per acre "beyond" the cost of seed or fertilizer.

Yields of primes were generally increased when the seed was spaced closer, but these increases were not always significant nor were they always economical from the standpoint of the cost of additional seed required. Of the three factors studied, seed spacing was found to have the greatest influence on yield, acting independently of row spacing except in one year.

The largest financial returns "beyond" estimated cost of seed and fertilizer were realized from seed spaced 15 or 18 inches in rows 36 inches apart and from the 2,000-pound application of fertilizer.

The average weight of prime tubers was increased when the seed was planted either farther apart in the rows or when the rows were spaced wider. These two factors were found to operate independently on size of tuber. The effect of varying the fertilizer rate on the size of tuber, however, was less pronounced than the effect from changes in the planting distances. Nevertheless, in 2 of the 3 years there was some indication from the interactions obtained that the effects of row spacing or of seed spacing were not independent of the amount of fertilizer applied.

Attention is called to the importance of making local tests to de-

termine, under the prevailing growing conditions, the most profitable planting distances for the particular potato variety used and the most profitable rate for the kind of fertilizer applied.

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CHROMATES AS POTATO FUNGICIDES[1,2]

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Recent announcement[6] of copper zinc chromates as foliage fungicides for potatoes is of special interest since materials of this type are probably the only new inorganic chemical compounds to show promise in this field in recent years. These chromates are complex chemical entities whose solubilities are of such a nature that solubility characteristics may be used to control the uniformity of the product, so far as fungicidal action and phytotoxicity are concerned. In addition they have very definite X-ray patterns which are used further to control the uniformity of the product. The chromate is a greenish-yellow free-flowing powder, of low water solubility. It is 100 per cent active, readily suspendible and presents no problems of handling or 1 use in the field.

Field tests with numerous chromates have been conducted for a number of years and tests on potatoes as early as 1942 demonstrated

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[1]The field work on which this report is based was conducted in part with funds supplied by Carbide and Carbon Chemicals Corporation—through the Crop Protection Institute.
[2]Authorized for publication in the Journal Series of the Penna. Agr. Exp. Sta. Published also with the approval of the Director, West Va. Exp. Sta. as scientific paper No. 394.
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[6]Phytopathology 38:27, Jan. 1948.

that with suitable proportions of zinc in the complex there was better control of tip burn than could be obtained with simple copper chromates or other forms of copper fungicidees. This was probably due to the control of leaf-hoppers. Rather large quantities (six pounds per 100 gallons) were required to obtain yields equal to or better than that Bordeaux (8-8-100).

For disease control, however, the field tests showed that a dosage of only 2 pounds per 100 gallons of a copper zinc chromate having suitable proportions of the metals (approximately 3, copper: 2, zinc: 1.2, chromium) could satisfactorily be used on potatoes. D.D.T., which is now generally accepted as a suitable insecticide for use on potatoes is compatible with the copper zinc chromate and is used in such proportions as may be necessary for insect control.

Two years of field tests with copper zinc chromate complexes of this type are reported here in comparison with other, better known, fungicides. These tests involved several varieties of potatoes and were conducted in three different states and in situations where early blight *Alternaria*, or late blight, *Phytophthora*, or both were important factors in affecting yields. In all tests D.D.T. was used in all plots including the check.

TABLE 1.—*Average yield in bus. per acre—Pennsylvania and West Virginia*—1946.

	Pennsylvania Russets	West Virginia Cobblers
Check	138	122
Bordeaux	227	179
Dithane	202	178
Tribasic	219	227
Copper Zinc Chromate	202	232

TABLE 2.—*Average yield in bus. per acre—Ohio*—1946

	Wooster	Marietta	McGuffy
Check	220	219	389
Bordeaux	365	491	548
Zerlate	414	498	540
COCS	356	481	563
Copper Zinc Chromate	381	493	583

It is of interest in 1946 that the copper zinc chromate produced the higher yield in two of the five trials reported (once in West Virginia and one in Ohio), whereas Zerlate was higher in two of the Ohio trials and Bordeaux in one, (on Russets in Pennsylvania).

TABLE 3.—*Correlation between late blight ratings and control yield.*

	1946 West Virginia	
	Rating	Yield
Check	119	122
Bordeaux	85	179
Dithane	84	178
Tribasic	57	227
Copper Zinc Chromate	43	232

Late blight was severe in West Virginia in 1946, and table 3 shows an interesting correlation between a late season rating of the plots for blight control and the yield obtained.

TABLE 4.—*Average yield in bus. per acre—Pennsylvania and West Virginia.*—1947.

	Pennsylvania		West Virginia	
	Russet	Katahdin	Cobbler	Sebago
Check	243	318	312	320
Bordeaux	315	363	293	300
Dithane	341	377	265	326
Parzate	339	374	—	—
Tribasic	328	382	297	242
Copper Zinc Chromate	320	390	324	307

TABLE 5.—*Average yield in bus. per acre—Ohio*—1947.

	Wooster	Marietta	McGuffy
Check	354	365	644
Bordeaux	455	491	815
Dithane	473	540	854
Parzate	453	502	826
Tribasic	494	496	789
Par. Alt. Zer.	550	566	844
Copper Zinc Chromate	518	586	806

In 1947, similar tests in the same areas showed copper zinc chromate to have produced the highest yields in three trials out of seven. Dithane also rated 3 top places and an alternating schedule of Parzate and Zerlate took the top yielding position once.

In the thirteen trials reported above one of the worst outbreaks of early blight was that which occurred at Marietta, Ohio, in 1947.

Table 6 gives some indication of the relationship between successful control of early blight and yield.

Many new fungicides have appeared in recent years, especially organic fungicides of the dithio carbamate group. The widespread accept-

TABLE 6.—*Correlation between early blight control and yield.*

	1947, Marietta, Ohio	
	Per cent Alive	Yield
Check	30	365
Bordeaux	55	491
Dithane	57	540
Copper Zinc Chromate	76	586

ance of D.D.T. and its use on potatoes would seem to have brought back into competition several materials which previous to D.D.T. had merely been "also rans." The potato grower today is often confused at the multiplicity of materials offered him. Copper zinc chromate adds to the list, and it is not to the confusion. Such data as have been obtained would indicate this material to be the most promising new inorganic potato fungicide introduced in recent years.

EUROPEAN METHODS FOR THE UTILIZATION OF POTATO STARCH FACTORY WASTES

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INTRODUCTION

In the course of a survey made in the summer of 1947 to determine European practices for the industrial utilization of white potatoes, some information was obtained on methods of utilizing the waste pulp and protein water from white potato starch factories.

Although no experiments have been made at this laboratory to determine the feasibility of the methods mentioned here, the information is nevertheless presented at this time because of current surpluses of white potatoes and the fact that the problem of waste disposal has already become serious in Maine potato starch-producing areas. It is hoped that the ideas presented may serve as a basis for study of this problem. They will be given consideration in the work at this Laboratory.

NATURE OF WASTES

The fluid wastes from a potato starch factory consist of a large amount of water containing dissolved proteins and sugars and small

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amounts of suspended starch and fiber. In Europe the potatoes used for starch manufacture contain, on the wet basis, about 18-½ per cent starch and from 2 to 2.5 per cent protein. About 0.13 pound of protein per pound of starch produced is lost in the watery wastes of a starch plant. This protein is in such low concentration in the combined effluents from a starch plant that its recovery would be quite out of the question.

It would have to be recovered at the steps in the process where it is most concentrated, for example, in the effluent from the protein water separator.

The potato pulp, with a moisture content of approximately 96 per cent is separated during the screening operations. The pulp can be diverted from the screens, and pressed and dried to make a feed supplement by the methods described here.

Recovery and Utilization of Wastes

What is perhaps the cheapest way to eliminate stream contamination and at the same time utilize part of the fluid factory wastes is to spray them on the fields after the potatoes have been harvested. Obviously this procedure would not be practical in hilly country. However, it is used with considerable success in Holland.

A 6-inch header is run from the factory into a field, and the effluents are pumped into this header at a pressure of 250 pounds per square inch. The header is provided with plugs so that branch headers with six outlets each can be attached successively at different points. These outlets are hose nozzles set at about 45° and arranged to rotate or oscillate. The effluent is sprayed on the area until the water on the ground is about 1 inch deep, and is then discharged on another area. For example, if three nozzles, each covering an area of 3,600 square meters, spray a total of 70 cubic meters of effluent in one hour, the total depth on 10,000 square meters (1 hectare) would be about 0.7 centimeter. Such an arrangement would thus have to be shifted about once every three hours to cover the ground to a depth of one inch. This does not allow for any absorption by the soil. Hence, the interval would actually be in excess of three hours. Likewise, a heater with six nozzles handling the same amount of effluent (70 cubic meters per hour) and covering double the area, would have to be shifted about once every six hours.

The spraying is done after the harvest, and the following spring, potatoes are planted on the sprayed field. Attempts to flood the fields without using spray has resulted in unequal distribution of the fertilizing elements and is not considered practicable. After the water has filtered

through about 2 feet of soil it is pure enough not to cause serious contamination of the canals.

Protein Recovery

Protein is not generally recovered in France or Holland. In Germany, however, where attempts were made to achieve a self-sufficient economy, this problem has been extensively studied.

The European practice, especially in Germany, is to remove the protein water from the freshly ground potatoes by diluting the slurry and passing it through either a Jahn or Uhland continuous centrifugal prior to removal of the pulp by screening. In the United States this is sometimes done, but more frequently removal of the pulp precedes removal of protein water. In either case, the effluent coming from the protein water, centrifugal separator generally contains about 1 per cent dissolved solids, about one-half of which is protein. The potato itself contains from 2.2 to 2.5 per cent protein. The low protein concentration in the centrifugal effluent results from diluting the ground potato with from 4 to 5 times its weight of water, which is necessary to achieve good protein removal. The various methods of protein recovery described here apply to these centrifugal effluents. It has been reported, however, that the Jahn Company has developed an improved centrifugal which would remove protein effectively without such high dilution of the slurry. Effluents with a protein content of approximately 2.8 per cent have been reported, but this seems questionable, as it would indicate the use of much less than an equal volume of dilution water per volume of ground potato.

One method reported to have been used on a commercial scale is to evaporate the protein water under vacuum at 45°C. to a concentration of about 48 per cent solids, that is, 35° Baumé. Forced circulation, single-effect evaporators are used. The liquid concentrate becomes extremely thick when cold. It is therefore discharged hot from the evaporator and mixed with dewatered potato pulp and then dried for feed. Büttner scraper-type dryers of the design employed for drying starch handle this product satisfactorily.

A procedure for recovering part of the protein to produce a product suitable for the enrichment of soups consists in carrying the vacuum evaporation only to between 15 and 18° Baumé. The concentrate is then removed from the evaporator and heated to 80°C. for approximately one hour. This causes the higher molecular weight proteins to precipitate. This precipitate is reported to be easily filterable in an ordinary plate and frame filter press. The dried product contains 75-80 per cent protein. About half the protein in the concentrate from the evaporator remains

in solution. The filtrate is therefore returned to the evaporator and mixed with incoming protein water.

Other experimenters found that the precipitate obtained by this procedure was difficult to filter and had to be recovered with a solid bowl centrifugal. In this case the product was mixed with pressed pulp and dried for feed. The feed had the following analysis on a moisture-free basis: 20 per cent protein, 45 per cent starch, and 35 per cent fiber.

Methods based on precipitation of the protein recover only approximately 50 per cent of it. A method which recovers all of it consists in evaporating the protein water under vacuum at a temperature of less than 45°C. in order to avoid precipitation and carrying the evaporation to nearly 65 per cent solids. It is then spray-dried. The product is a dark-brown powder with a salty, agreeable flavor and has been reported to contain about 45 per cent protein. It has found some use in soups.

It is questionable whether any of these methods would prove profitable as a source of protein, but one or more of them might be justified on the basis of reducing stream contamination.

Pulp Recovery

In small potato starch factories the wet pulp is frequently accumulated in pits, from which it is hauled to local farms for hog feed. In the larger plants in Germany, Holland and France, however, the pulp is dewatered (with or without liming), usually in roller presses of the Büttner type, and is then dried. Drying can be done in steam tube dryers; in Büttner scraper-type dryers of the type used for starch; in direct heat, parallel-flow, high-temperature dryers; and in blast-type flash dryers. From 2 to 6 per cent of the original weight of the potato is obtained as pulp. The product usually contains about 6 per cent protein and 40 per cent starch on a moisture-free basis. It is used for cattle feed either by itself or mixed with recovered protein.

There seems little question but that pressing and drying pulp would be a desirable operation in our starch plants. The process is simple, and the value of the product as a feed should exceed the cost of preparing it. Information on processing potato pulp for feed may be found in AIC-204, "Recovery and Utilization of Pulp from White Potato Starch Factories." This was recently published by the Bureau of Agricultural and Industrial Chemistry and may be obtained from the Eastern Regional Research Laboratory, Philadelphia 18, Pennsylvania.

OFF-FLAVOR OF POTATO TUBERS PRODUCED BY BENZENE HEXACHLORIDE USED FOR WIREWORM CONTROL

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In testing benzene hexachloride for insect control the problem of taste contamination of food products has arisen. Benzene hexachloride may be used for control of some insects without regard to any taste contamination but taste must be considered in its use for control of wireworms on potatoes. This material has been reported promising or as very effective in wireworm control on potatoes by Greenwood (1947), Pepper, *et al* (1947), and Wolfenbarger (1948). Each of these writers has mentioned the off-flavor of tubers from benzene hexachloride treatments. They admited some off-flavor but indicated that most people did not detect flavor impairment when small amounts of the insecticide were used. A consideration of different amounts of benzene hexachloride applied per acre as related to the off-flavor tasted by different people is presented here.

The constituent of benzene hexachloride causing the off-flavor is as yet not fully understood. It is suspected of being one of the isomers, alpha, beta, or delta. The gamma-isomer is the most effective insecticidal constituent of crude benzene hexachloride. Refined materials, having high gamma-isomer content and an absence or reduced content of the other isomers have been prepared, which it was hoped might eliminate the off-flavor. Some degree of success may have been attained with the refined "high gamma content" benzene hexachloride but further tests are in progress to determine any improvement.

Some people seem to taste the benzene hexachloride contaminant in much more minute quantities than others. This has been termed "threshold," or "minimum stimuli" by Moncrieff (1946), and is an expected occurrence. Part of the taste detection comes from previous experience in handling or testing the material. Some who never experienced the odor of benzene hexachloride have simply detected an objec-

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tionable taste in products treated with it. In any event, rejection of certain commercial lots of food products has been experienced, caused apparently by the off-flavor imparted to plant products by benzene hexachloride treatments.

Materials and Methods—The tubers used for the tests reported here were taken from field experiments in which soil and potato seed pieces had been treated with crude, unrefined benzene hexachloride as reported by Wolfenbarger (1948). Several tubers were taken from each lot for tasting. The unpared tubers were washed and boiled in water, and then they were placed on tables for the tasters to sample. Non-professional tasters, mostly experiment station, college and university personnel, were used in the tests, although graduate students, growers, and others comprised a minor portion of the tasters. Each taster was asked to taste one or more tubers in each lot and to place it in one of the three classifications, as follows: (1) the ordinary or unimpaired potato flavor, (2) questionable flavor, and (3) a positive or definite off-flavor. Three groups of people in three different locations did the tasting, each under the direction of one of the authors. A total of 37 people comprised the tasters.

Results—The placements by individuals were variable and ranged from reporting off-flavor for the check (non-treatments) to ordinary potato flavor for the sample from the highest dosage concentration, as is shown in table 1. Some samplers reported that most sample lots were in the ordinary or unimpaired potato flavor category.

TABLE 1.—*Summarization of taste test data, given in percentage.*

Treatment, Lbs. Gamma-isomer Used per Acre*	TASTE CLASSIFICATION								
	Ordinary Potato			Questionable Group Results			Off-Flavor		
	A	B	C	A	B	C	A	B	C
0.88	67	93	72	33	7	7	0	0	21
1.76	56	57	64	33	36	36	11	7	0
3.52	45	50	36	33	29	36	22	21	28
0	89	100	72	11	0	14	0	0	14
3.0	78	64	36	0	36	36	22	0	28
8.3	33	86	43	11	0	21	56	14	36
1.7	44	50	72	44	14	21	12	36	7
0	67	72	93	22	21	0	11	7	7
1.8	44	86	64	56	14	7	0	0	29

*The first four treatments were samples from one experiment, the lower five were from another. The 0.88, 1.76, 3.52 and 8.3 pounds of gamma-isomer were applied with the fertilizer, in bands at the sides of each row. The 3.0, and 1.8 pounds-treatments were broadcast over the soil and disked in, whereas the 1.7 pounds-treatment was a seed piece treatment, and the 0 pounds were check or untreated groups.

Certain tasters, however, tended to report the samples from the check lots as ordinary flavor, and the treatment lots as questionable, or off-flavor, depending somewhat on the amount of benzene hexachloride used. These tasters indicated some real ability to detect the off-flavor produced by the benzene hexachloride.

Since the variations indicated above were obtained, it was deemed desirable to study the mass of data in table 1. In view of the sampling technique and of the method of classification the data were converted to percentages for each sample lot of tubers for each group.

Simple analysis of variance determinations showed that sampling variations might account for the difference between treatments and locations where the classifications "questionable," and "positive off-flavor," were each analyzed separately. Transformation of the data to angles followed by an analysis of variance made no change in the conclusions. After treating the data of all classifications together, by a more complex analysis of variance it was concluded that the classifications "ordinary potato flavor," "questionable," and "positive off-flavor" varied significantly among the treatments, more than could be expected by chance occurrence. Variations among the different locations were unimportant.

A positive relationship was found in which increasingly more tasters reported off-flavor with increases in the amount of benzene hexachloride applied per acre. Trends of this relationship are observed in the data recorded in table 1. These trends are studied by the data from the "Off-Flavor" columns shown in table 1. The average for each treatment was determined and used for a graph, shown in figure 1. It illustrates that the more gamma-isomer used per acre, the more tasters reported off-flavor. The regression line, drawn by mathematical determinations, was found to have a positive significant slope. The formula for the determination of the line is as follows:

$$\text{Expected percentage} = 3.5644\ (\text{pounds gamma-isomer}) + 7.2211.$$

The regression line drawn for the "questionable" classification was nearly flat. The "ordinary flavor" line had considerable slope but in the opposite direction to the line illustrated in figure I.

In the collection of these data, certain weaknesses were observed. The off-flavor leaves a lingering taste, hence dissipation of the flavor before the taster takes another sample lot is an important factor in order to avoid mixing flavors. Some tasters smoked between lots and some washed their mouths with water to clear the lingering taste. There were too many (9) lots to taste within the space of several minutes or the few hours devoted to it. Different tubers in the same lot tasted differently,

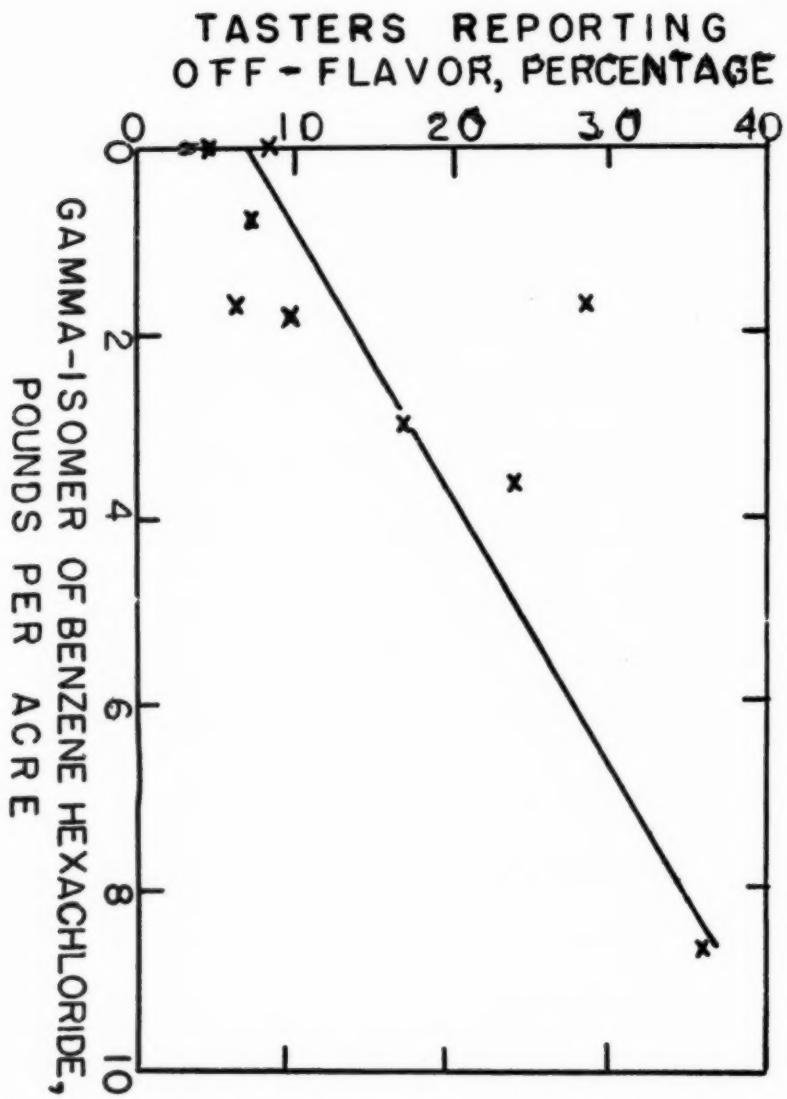

FIGURE 1. Percentage of tasters reporting off-flavor of potatoes from soil treated with different amounts of gamma-isomer of benzone hexachloride.

according to some tasters. The taste was not immediate to some but became apparent later, hence some time should elapse between exposing the sample to the taste buds and recording the results. These variations are apparently to be expected in view of the discussions given by Moncreiff (1946).

Summary:—Samples of potato tubers from experiments conducted for wireworm control were tasted for benzene hexachloride off-flavor. Tubers from soil applications, fertilizer combinations, seed pieces treated with benzene hexachloride, and tubers from check or untreated lots were used in taste tests conducted at three different places. Those who tasted the different samples showed wide variations in their abilities to detect and to determine off-flavor of the tubers. A positive relationship was observed, however, in which samples of potatoes from the higher dosage concentration treatments expressed as pounds of gamma-benzene hexachloride applied per acre were more frequently recorded as off-flavor than those of lower concentrations or of the checks.

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SECTIONAL NOTES

Maine

The Maine Department of Agriculture has announced that 31,958 acres passed certification this year. The Katahdins showed a big increase, but the Cobblers decreased from approximately 10 thousand to 6 thousand acres. Altogether 15 varieties were certified in 1948.

A State Potato Committee was recently elected to administer the Marketing Agreement. W. L. Berce of Washburn, T. E. Houghton of Caribou, Norman Guy of Fort Kent, Ralph Howard of Houlton, and Keith Smith of Exeter represent the growers. Harold Daigle, Fort Kent; S. A. Wathen, Fort Fairfield; and Millard Otto of Exeter represented the dealers at an open meeting at which every one had an opportunity to express one's self on the matter of grade qualifications. Regulations effective on the 15th of November will allow shipment of 2¼ to 4-inch table stock. Only certified seed will go under previous regulations. The Committee has selected Herbert W. Moore to serve as manager. Moore served as Executive Secretary of the Potato Industry Council and is well qualified to serve the potato committee also.

Maine has harvested a banner crop. The yield per acre of 380 bushels

is the highest on record. An excellent fall season resulted in the crop being dug in fine shape. The snow storm and the cold weather which were experienced about the 16th of October, found more than 90 per cent of the potatoes harvested. Most of the crop harvested after that date was placed in cars and shipped under the Support Program, so any stock which might later have caused trouble has been pretty well disposed of. The crop in storage, therefore, is quality crop. Maine has shipped, as of the 4th of November 6,346 cars, of these the Government has purchased approximately 5,400 cars but these have been loaded so heavily that it is equivalent to approximately 8,200 cars of potatoes.

Some discussions regarding potato allotment and price support have occurred in Maine, but there has been no concerted move to discuss this problem as an industry program.

A survey of Maine growers shows that the Blue Tag Certified Seed Campaign conducted last winter was very successful. A scientific sample of Aroostook growers shows that 85 per cent of the potato acreage was planted with certified seed and another 9 per cent with seed produced in the farmer's own seed plot. This leaves only about 6 per cent of our 1948 acreage being planted with common table stock potatoes. These figures indicate that more than 15 to 20 per cent of Maine's acreage was planted with high quality seed than has ever been used in the past.

New York

Marketing Agreements are receiving a lot of attention. After a joint meeting of the Long Island and New Jersey delegates, a meeting was held in Riverhead this week to explore further the possibilities of starting a Marketing Agreement at once for effective use next fall.

In up-state New York Marketing Agreements have been considered for two years with no definite action. Recently the directors of the New York Cooperative Seed Potato Association which handles more table stock than any other similar organization in the state, went on record as approving the principle of Marketing Agreements and will submit the Marketing Agreement program at our Annual Meeting in December. If the members approve they will assume leadership in sounding out the rest of the up-state growers.

Up-state growers are keenly interested in improving the quality of potatoes going to market and are quite disappointed in having such a large percentage of our crop going into various processing operations. This attitude is a strong factor for promoting Marketing Agreements.

At the Annual Seed School being held at Ithaca from the 22nd-23rd of November the Future of the Certified Potato Industry will be one of

the subjects discussed by growers, distributors and users. Growers of Certified Seed are somewhat discouraged at the narrow margin over table stock prices for seed produced from foundation stock under one of the most rigid inspections and standards in the country. Buyers and users seem reluctant to pay more for quality certified seed than for anything that is eligible to carry a tag. Some interesting angles will be brought out in this discussion.

The crop was one of the largest in the history of the state but is moving to market and to Commodity Credit Corporation outlets in good volume. The surplus will have been moved before freezing weather. — H. J. Evans.

Oregon

To date, 860 acres of Russets have met certification or foundation requirements and 550 acres of White Rose, with a total of 1410 in Klamath County. This is considerably in excess of the acreage approved last year and speaks well for the past two years for the program of seed improvement carried on cooperatively by the Klamath Potato Growers' Association, Klamath County, and the Oregon Extension Service and Experiment Station. As a result, yields are much better and the general quality of pack is greatly improved.

Potato digging was more than 80 per cent completed on the 20th of October. Shipments have been light and the interest in certified seed to date has not been too strongly marked. — C. A. Henderson.

Pennsylvania

In 1948 Pennsylvania harvested not only its highest yield per acre but also crops of the highest quality in its history. Many growers are recording yields well above 750 bushels per acre. Katahdin still remains the standard variety in the state although some of the new blight-immune varieties looked especially fine. Essex yielded high even under dry conditions and although the tubers were not so smooth as Katahdins they presented a good appearance. Kennebec came in second to Essex in both respects; *i.e.*, in yield and appearance. Teton has made a good showing since ring rot seemed more common than ever before.—O. D. Burke.

South Dakota

The best potato crop in a number of years has now been harvested in South Dakota and to date nearly 800 cars and 190 trucks have been shipped. All warehouses are filled and this includes at least 10 new storage houses that were constructed this season. Last year the total shipments from South Dakota were under 1000 cars. The Government has purchased 375 cars with the bulk of these being Number 2 grade

which will be used for alcohol. Some shipments have also been made to Wisconsin for livestock feed.

The Marketing Agreement which prohibits the shipping of potatoes grading less than U. S. Commercial, went into effect on the 15th of September and it was necessary to get a restraining order against one grower who was not eligible for price support and who insisted on marketing field run potatoes after being warned that this violated the Marketing Agreement.

The Government crop report as of the 1st of October estimated the South Dakota potato crop at 2,160,000 bushels harvested from 22,000 acres. It is estimated that 12,000 acres of potatoes were harvested in the Watertown, Clark and Garden City areas with a yield of almost 2,000,000 bushels.

The potato acreage in South Dakota has been decreasing because of the Government programs and the shifting of acreage to larger growers who can afford to maintain modern equipment. Many small growers with an acreage of 4 to 15 have gone out of the business since it is not economical to buy up-to-date machinery for small acreages.

Hollow Heart has been found in Irish Cobblers, Pontiacs and LaSalle potatoes. This will not affect them for seed but it is hard for growers to make the Federal grades because in many cases the damage will exceed 5 per cent.

Of the 7,000 acres entered for certification this year 6,407 passed field inspection. This consisted of 3,907 acres of Bliss Triumphs; 1,499 of Irish Cobblers; 698 of Pontiacs; 175 Red Warbas; and the balance were Early Ohios, White Rose, Russet Burbank, LaSalle and White Warbas. — JOHN NOONAN.

WASHINGTON

There is a plentiful supply of good certified seed potatoes in the state. The tests of these potatoes are now being planted in California and early in January we should know how they are turning out. On the basis of the amount of virus diseases in the field, the tests should be quite satisfactory.

Aside from virus diseases, two fields of potatoes were rejected for the presence of ring rot. One of these was the White Rose variety and another the Netted Gem. Nearly all the Washington potatoes have been harvested. The farmers did not get so high a yield in quite a few fields as last year but still did quite well. Very little has been said so far about reducing acreage or maintaining of support prices, but those who have

expressed an opinion seem to feel that they should like the support price to continue and hope that they will be able to have enough acreage to make potato-growing a profitable enterprise.

The State of Washington is unfortunate in losing the services of Harold Shaad who is leaving to become a farmer. His long service with the State Department and his successful work in certifying seed makes his replacement a difficult task. — M. R. HARRIS.

PROVINCE OF OTTAWA

The potato crop in Canada is practically harvested. In most areas the yields have been exceptionally good and the quality is high.

The damage from late blight has been much lower than was anticipated earlier in the season. Although the total acreage passed in 1948 is higher than in 1947, the total yield for all Canada is estimated at approximately the same as last year, which was 11,474,000 bushels. The average yield of graded stock in 1947 was 219 bushels per acre, whereas in 1948 it was 207 bushels.

The foremost popular varieties continue to be Katahdin, Irish Cobbler, Green Mountain and Sebago — in that order — with, of course, Netted Gem and White Rose being the predominant varieties on the west coast. The production of Chippewa is largely confined to northern Ontario, and Sequoia to Prince Edward Island.—J. W. SCANNELL.

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PROGRAM OF THE ANNUAL MEETING OF THE POTATO ASSOCIATION OF AMERICA

December 6, 7, 8, 1948
Hotel Fort Pitt
Pittsburgh, Pennsylvania

President, E. L. NEWDICK, *Department of Agriculture, Augusta, Maine*

Monday Morning, December 6, Hotel Fort Pitt, Assembly Room, 9:30 A. M. Society Session.

JOHN C. CAMPBELL, *Presiding*

1. *Control of Weeds in Potatoes by Pre-emergence Sprays* (15 min.) ORA SMITH, M. W. MEADOWS and E. R. MARSHALL, Cornell University, Ithaca, N. Y.
2. *Revolutionary Changes in Potato Production as a Result of Chemical Weed Control* (15 min.) ORA SMITH, E. R. MARSHALL and M. W. MEADOWS, Cornell University, Ithaca, N. Y.
3. *Effect of Vine Killers and Environmental Factors on Vascular Discoloration in Potatoes* (15 min.) M. W. MEADOWS and ORA SMITH, Cornell University, Ithaca, N. Y.
4. *The Effect of Incorporating 2, 4-D in the Regular Spray on the Yield of White Potatoes* (15 min.) N. E. ELLIS, Purdue University, Lafayette, Ind.
5. *Potato Vine Killing in Prince Edward Island* (15 min.) L. C. CALLBECK, Department of Agriculture, Charlottstown, P. E. I., Canada.
6. *Chemical Weed Control Results in 1948* (15 min.) J. STANLEY COBB, Pennsylvania State College, State College, Pa.
7. *Sprout Inhibition of Non-dormant Chippewa Potatoes* (15 min.) R. H. BRADLEY and LESLIE L. DEAN, Purdue University, Lafayette, Ind.
8. *Effect of Type of Container on the Shrinkage of Stored Potatoes* (10 min. lantern). E. V. HARDENBURG, Cornell University, Ithaca, N. Y.

Monday Afternoon, December 6, Hotel Fort Pitt, Assembly Room 1:30 P. M. Society Session.

ORA SMITH, *Presiding*

1. *Utilization of Potatoes. Production of Useful Fermentation Products* (15 Min.) R. H. TREADWAY and T. C. CORDON, Eastern Regional Research Laboratory, U. S .D. A., Philadelphia, Pa.
2. *Conversion of Potatoes to a Stable Form* (30 min. lantern). R. K. ESKEW, Eastern Regional Research Laboratory, U. S. D. A., Philadelphia, Pa.
3. *Progress in Potato Utilization* (20 min.) R. H. TREADWAY, Eastern Regional Research Laboratory, U. S. D. A., Philadelphia, Pa.
4. *General Discussion — Potato Utilization* (15 min.)
5. *Unusual Variegations in the Sebago Potato*
   1. *Somatic Mutations* (15 min.) W. W. WEBER and G. H. RIEMAN, University of Wisconsin, Madison, Wis.
   2. *Pathological Aspects* (15 min.) R. W. HOUGAS and G. H. RIEMAN, University of Wisconsin, Madison, Wis.

6. *Results of Two Year Tests with Potato Varieties* (15 min.) W. R. MILLS and O. D. BURKE, Pennsylvania State College, State College, Pa.
7. *A New Red Variety of Potatoes Developed in Nebraska* (15 min.) H. O. WERNER, University of Nebraska, Lincoln, Nebr.
8. *Discussion* 15 min.

Tuesday Morning, December 7, Hotel Fort Pitt, Assembly Room 9:00 A. M. Society Session-Business Meeting.

E. L. NEWDICK, *Presiding*

10:30 A. M. *Open Forum—Certification Problems.* Discussion led by R. C. HASTINGS.

Tuesday Afternoon, December 7, Hotel Fort Pitt, Assembly Room 1:30 P. M. Society Session.

HAROLD MATTSON, *Presiding*

1. *Response of Potatoes to Rates and Placement of Nitrogen in Connecticut, 1948* (15 min.) ARTHUR HAWKINS, University of Connecticut, Storrs, Conn.
2. *The Influence of Irrigation on the Nitrogen, Phosphorus and Potash Requirements of Several Potato Varieties* (30 min., lantern), WALTER C. JACOB, Long Island Vegetable Research Farm, Cornell University, Riverhead, N. Y.
3. *Some Effects of Restricting the Oxygen Supply of Potato Roots* (15 min., lantern), JOHN BUSHNELL, Ohio Agricultural Experiment Station, Wooster, Ohio.
4. *Report on Fertilizer and Cultural Investigations in* 1948 (10 min.) ORA SMITH, Cornell University, Ithaca, N. Y.
5. *General Discussion — Potato Culture* (10 min.).
6. *The Comparative Efficiency of Tuber Indexing and Tuber-unit Planting in the Elimination of Virus Diseases from Seed Potatoes* (15 min.) H. N. RACICOT, Department of Agriculture, Ottawa, Ontario, Canada.
7. *Some Observations on the Bunch-top (Purple-top) Disease in Canada* (20 min. lantern), D. J. MACLEOD, Department of Agriculture, Fredericton, New Brunswick, Canada.
8. *Report on Virus Disease Investigations* (15 min.) R. H. LARSON, University of Wisconsin, Madison, Wis.

Wednesday Morning, December 8, Hotel Fort Pitt, Assembly Room, 9:00 A. M.—Society Session.

W. D. KIMBROUGH, *Presiding*

1. *Experiences with Aerial Application of Insecticides and Fungicides.* (30 min. moving picture), JOSEPH P. MCKENNA, Vahlsing Insecticide and Chemical Corporation, Robbinsville, N. J.
2. *Potato Blight Investigations* (15 min. lantern), W. R. MILLS, Pennsylvania State College, State College, Pa., and L. C. PETERSON, Cornell University, Ithaca, N. Y.
3. *Spraying Potatoes for the Control of Diseases and Insects in Maine* (15 min.) REINER BONDE, Maine Agricultural Experiment Station, Orono, Maine.

4. *The Effects of Zinc-containing Sprays and Dusts on Potatoes* (15 min., lantern) WILLIAM C. HOYMAN, North Dakota Agricultural Experiment Station and State Seed Department, Fargo, N. D.
5. *Results of Insecticidal Applications to Potatoes in North Dakota During* 1948 (15 min.) R. L. POST, WAYNE J. COLBERG and J. ALEX MUNRO, North Dakota Agricultural Experiment Station and State Seed Department, Fargo, N. D.
6. *Results of Spraying and Dusting Potatoes for Late Blight* (15 min.) L. C. CALLBECK, Department of Agriculture, Charlottetown, Prince Edward Island, Canada.
7. *Field Tests of Fungicide-Insecticide Combinations in Michigan for* 1948. (15 min.) J. H. MUNCIE and W. F. MOROFSKY, Michigan State College, East Lansing, Mich.
8. *A Summary of Recent Investigations on Wireworm Control with Organic Insecticides in New Jersey* (15 min.) BAILEY B. PEPPER, J. P. REED, and JOHN C. CAMPBELL, Rutgers University, New Brunswick, N. J.
9. *Results of the National Cooperative Potato Spray Fungicide Experiment in* 1948 (20 min.) W. F. BUCHHOLTZ, Iowa State College, Ames, Iowa.
10. *Insect Investigations in* 1948 (15 min.) A. A. GRANOVSKY, University of Minnesota, St. Paul, Minn.

Wednesday Afternoon, December 8, Hotel William Penn, Monongahela Room, Joint Session with The American Phytopathological Society.

W. R. MILLS, *Presiding*

1. *Transmission of Purple-Top of Potatoes.* (15 min., lantern) R. L. SELF and H. M. DARLING, University of Wisconsin, Madison, Wis.
2. *Reaction of Potato Varieties to the Virulent Ringspot Virus.* (15 min., lantern) R. C. LADEBURG and R. H. LARSON, University of Wisconsin, Madison, Wis.
3. *Isolation of Virulent Ringspot Virus from "Healthy" Potatoes.* (15 min., lantern) R. H. LARSON and R. C. LADEBURG, University of Wisconsin, Madison, Wis.
4. *The Effect of Various Diluents on the Infectivity of the Potato X Virus.* (15 min., lantern) R. E. WILKINSON and A. FRANK ROSS, Cornell University, Ithaca, N. Y.
5. *Potato Virus Disease Research in Mexico.* (15 min.) JOHN S. NIEDERHAUSER Rockefeller Foundation, Mexico D. F., Mexico.
6. *Effect of the Leaf Roll and X Viruses on Stand and Yield of Potatoes.* (10 min., lantern) R. E. WILKINSON and F. M. BLODGETT, Cornell University, Ithaca, N. Y.
7. *Some Specific Characters of Erwinia atrospetica* (van Hall) Jennison *and Erwinia carotovora* (Jones) Holland. (15 min.) WILSON L. SMITH, JR., Cornell University, Ithaca, N. Y.
8. *Location of Bacteria in Healthy Potato Tissue.* (10 min., lantern) J. P. HOLLIS, University of Nebraska, Lincoln, Nebr.
9. *Factors Affecting Lesion Formation on Physalis floridana.* (15 min. lantern) A. FRANK ROSS, Cornell University, Ithaca, N. Y.
10. *Reaction of Hybrid Potato Varieties to Infection by Fusarium eumartii.* J. H. MUNCIE, Agricultural Experiment Station, East Lansing, Mich.
11. *Aphid Transmission of Potato Virus Diseases in Storage.* (10 min., lantern) A. A. GRANOVSKY, University of Minnesota, St. Paul, Minn.

STATEMENT OF THE OWNERSHIP, MANAGEMENT, CIRCULATION, ETC., REQUIRED BY THE ACT OF CONGRESS OF AUGUST 24, 1912.

Of American Potato Journal, published monthly at New Brunswick, New Jersey, for November 18, 1948.

State of New Jersey
County of Middlesex ss

Before me, a Notary Public in and for the state and county aforesaid, personally appeared H. H. Martin, who having been duly sworn according to the law, deposes and says that he is the Editor of the American Potato Journal and that the following is, to the best of his knowledge and belief, a true statement of the ownership, management (and if a daily paper, the circulation), etc., of the aforesaid publication for the date shown in the above caption, required by the Act of August 24, 1912, embodied in section 411. Postal Laws and Regulations, printed on the reverse of this form, to-wit:

1. That the names and addresses of the publisher, editor, managing editor, and business managers, are:

Publisher—Potato Association of America, New Brunswick, New Jersey.
Editor—W. H. Martin, New Brunswick, New Jersey.
Business Manager—John C. Campbell, New Brunswick, New Jersey.

2. That the owner is: (If owned by a corporation its name and address must be stated and also immediately thereunder the names and addresses of stockholders owning or holding one per cent or more of total amount of stock. If not owned by a corporation, the names and addresses of the individual owners must be given. Of owned by a firm, company, or other unincorporated concern, its name and address, as well as those of each individual member, must be given).

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3. That the known bondholders, mortgagees, and other security holders owning or holding 1 per cent or more of total amount of bonds, mortgages, or other securities are: (If there are none, so state). None

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5. That the average number of copies of each issue of this publication sold or distributed through the mails or otherwise, to paid subscribers during the six months preceding the date shown above is—(This information is required from daily publications only).

W. H. MARTIN, Editor.

Sworn to and subscribed before me this 18th day of November, 1948.
R. E. Long, Notary Public, Middlesex County, New Jersey.
(My Commission Expires January 31, 1949).
Form 3526—Ed. 1924.

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